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Rothwell

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(54) **WALL PANEL INVERTER AND PREFABRICATION METHOD**

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This patent is subject to a terminal disclaimer.

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(51) **Int. Cl.**

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B65G 47/90	(2006.01)
B27M 1/08	(2006.01)
B23Q 7/04	(2006.01)

(52) **U.S. Cl.**

CPC ***B65G 47/904*** (2013.01); ***B27M 1/08*** (2013.01); *B23Q 7/04* (2013.01); *B23Q 2240/002* (2013.01)

(58) **Field of Classification Search**

CPC B65G 47/252; B65G 47/248; B65G 47/02

USPC 414/754, 758, 771, 776, 759; 198/379

See application file for complete search history.

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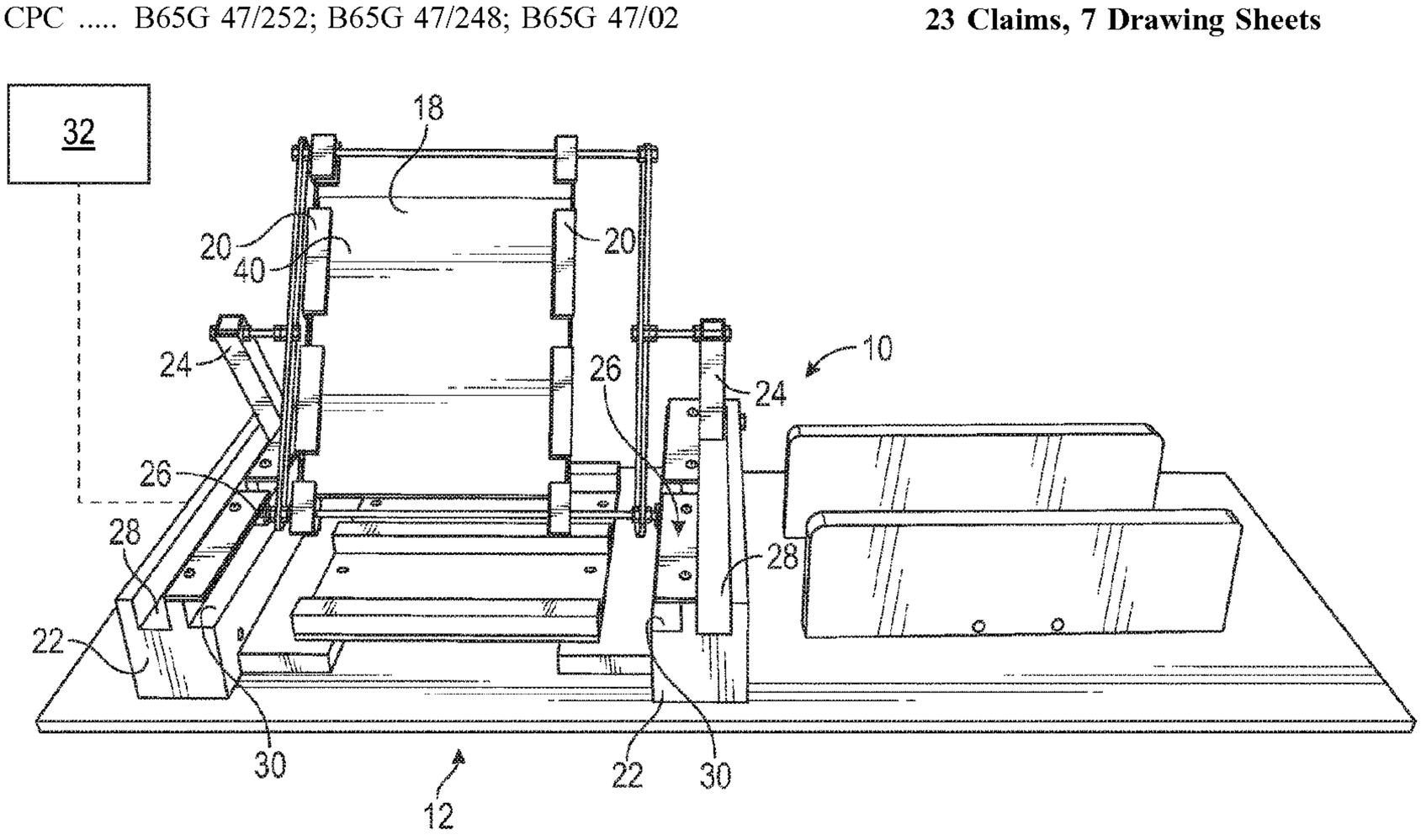
(57) **ABSTRACT**

An inverter manufacturing cell includes a table including a base, a frame configured to receive a work piece, and at least one pivotable lift arm attached to the base and to the frame. The pivotable lift arm is configured to pivot relative to the base about at least one axis such that the frame and work piece rotate from a first, generally horizontal position to a second, generally vertical position. After rotating to the second, vertical position, the frame is configured to slide such that the frame and work piece further rotate to a third, generally horizontal position wherein the frame and work piece are inverted relative to the first, generally horizontal position.

23 Claims, 7 Drawing Sheets



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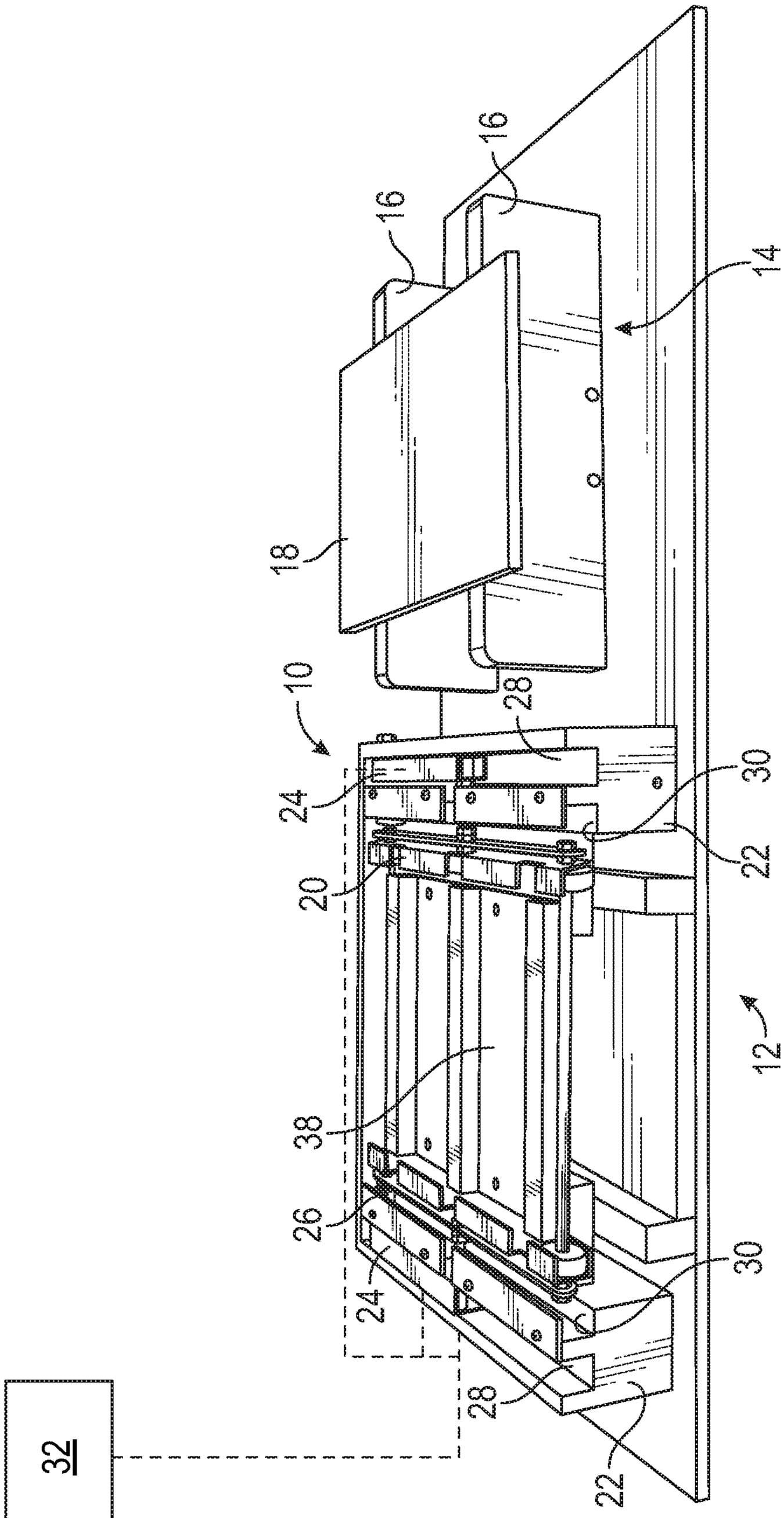

FIG. 1

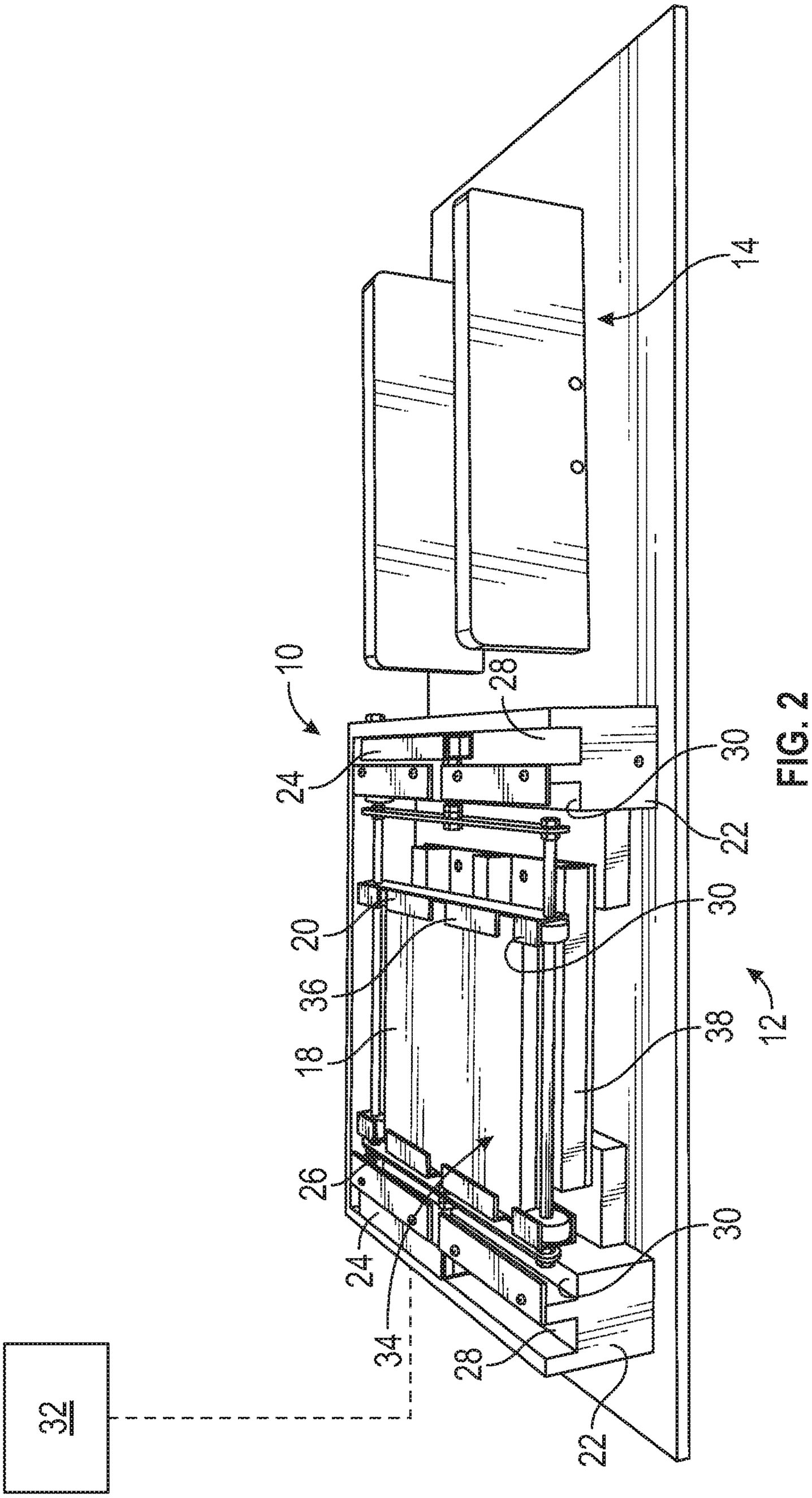

FIG. 2

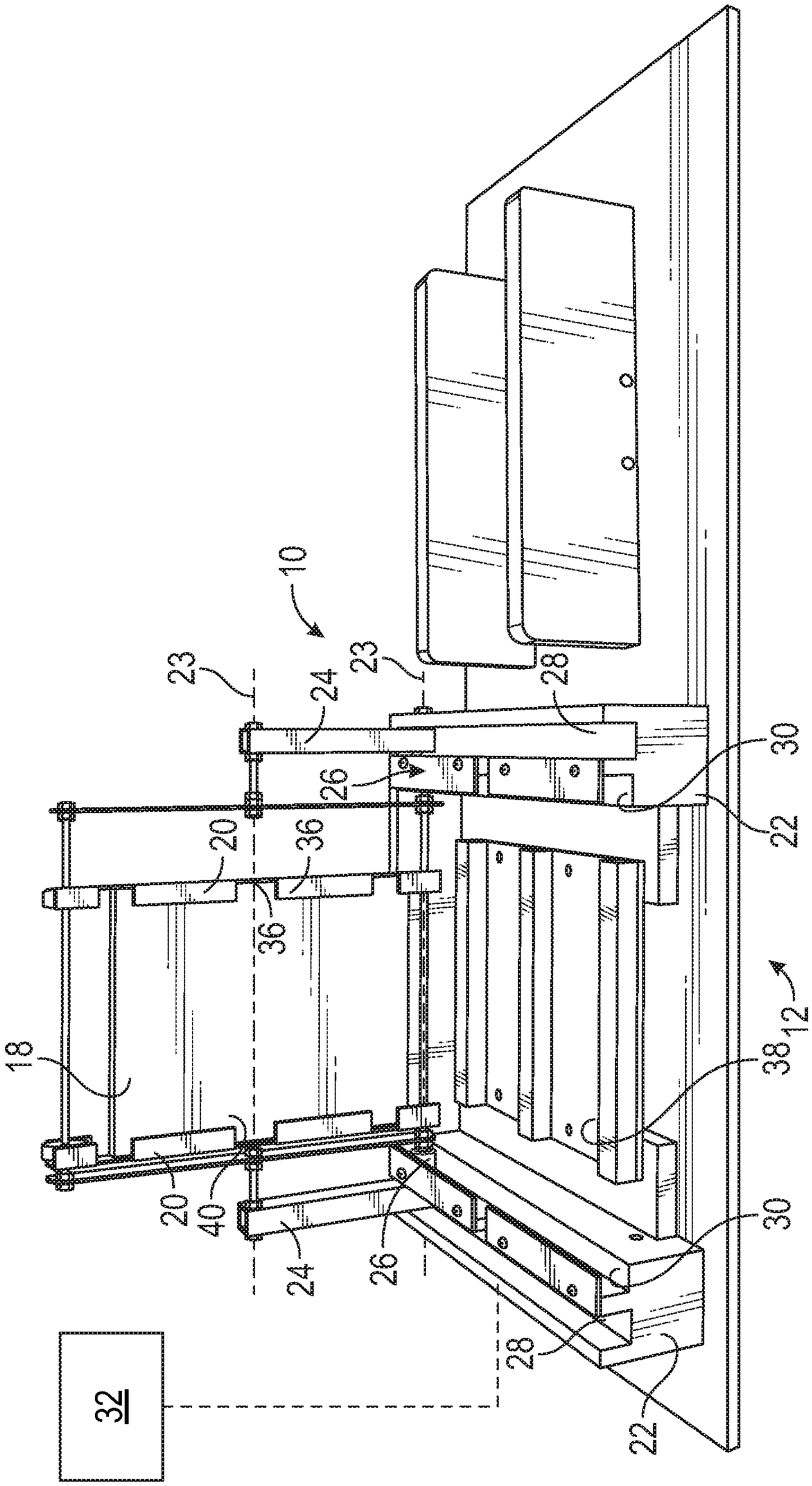

FIG. 3

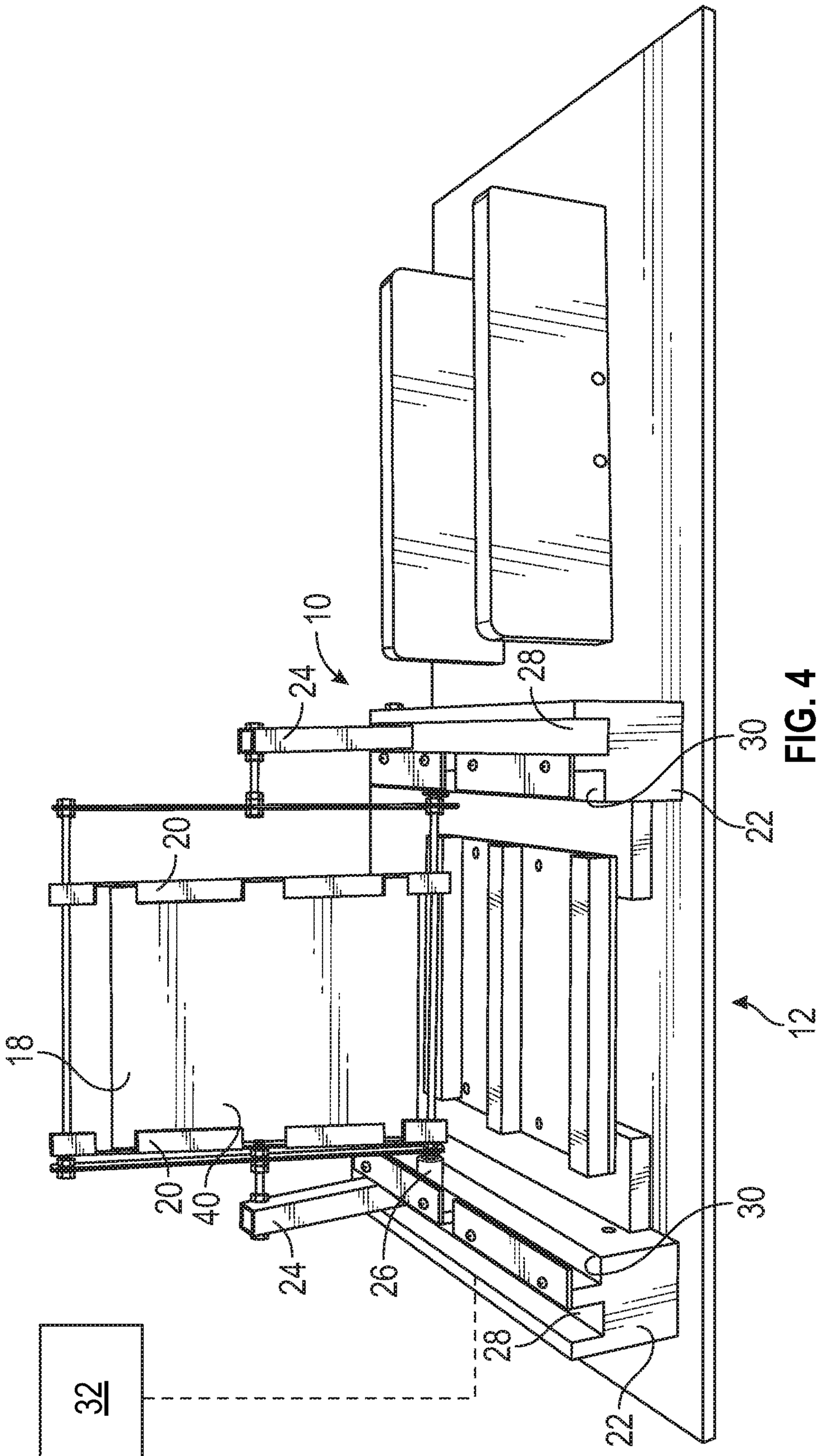

FIG. 4

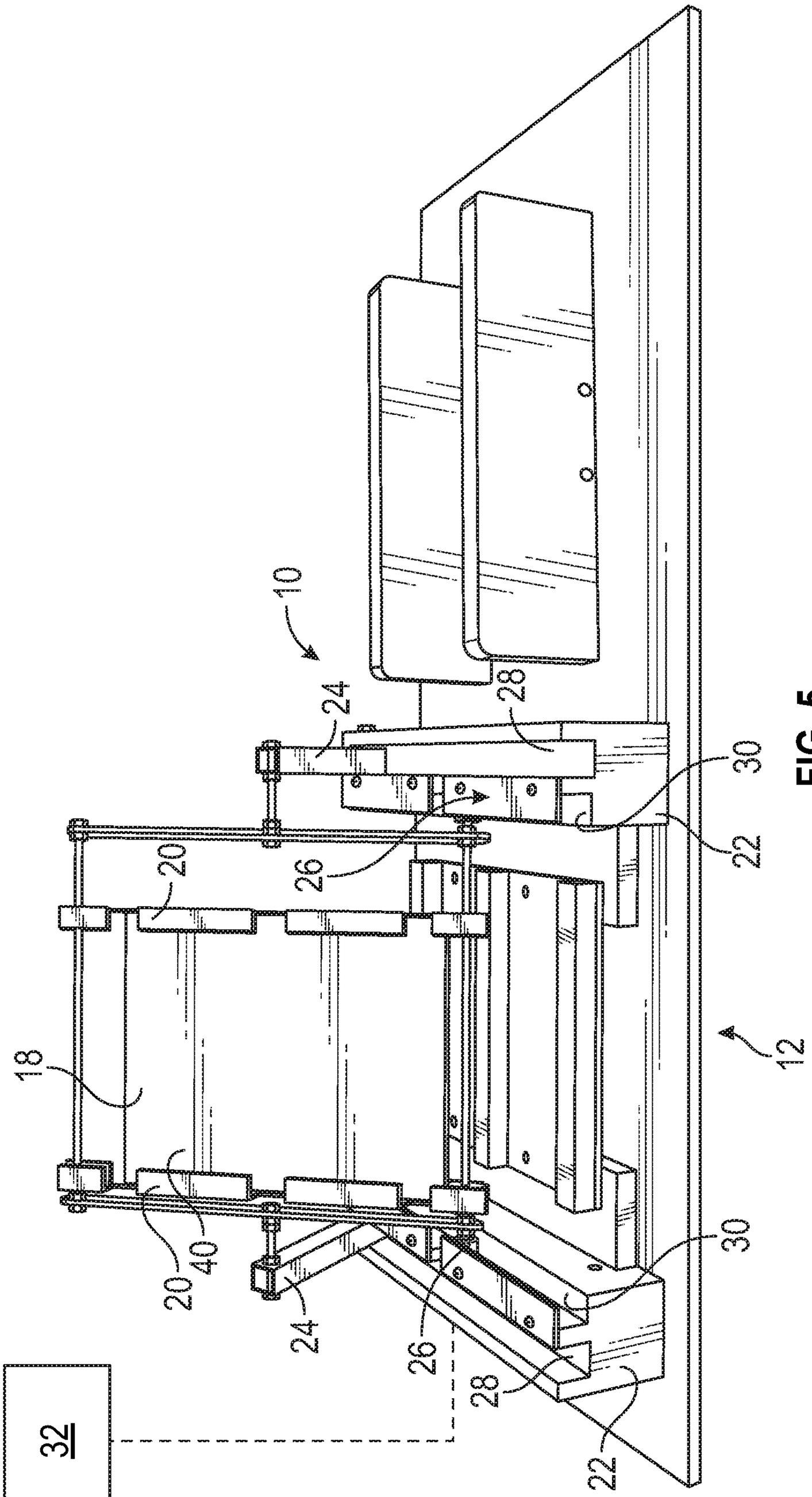

FIG. 5

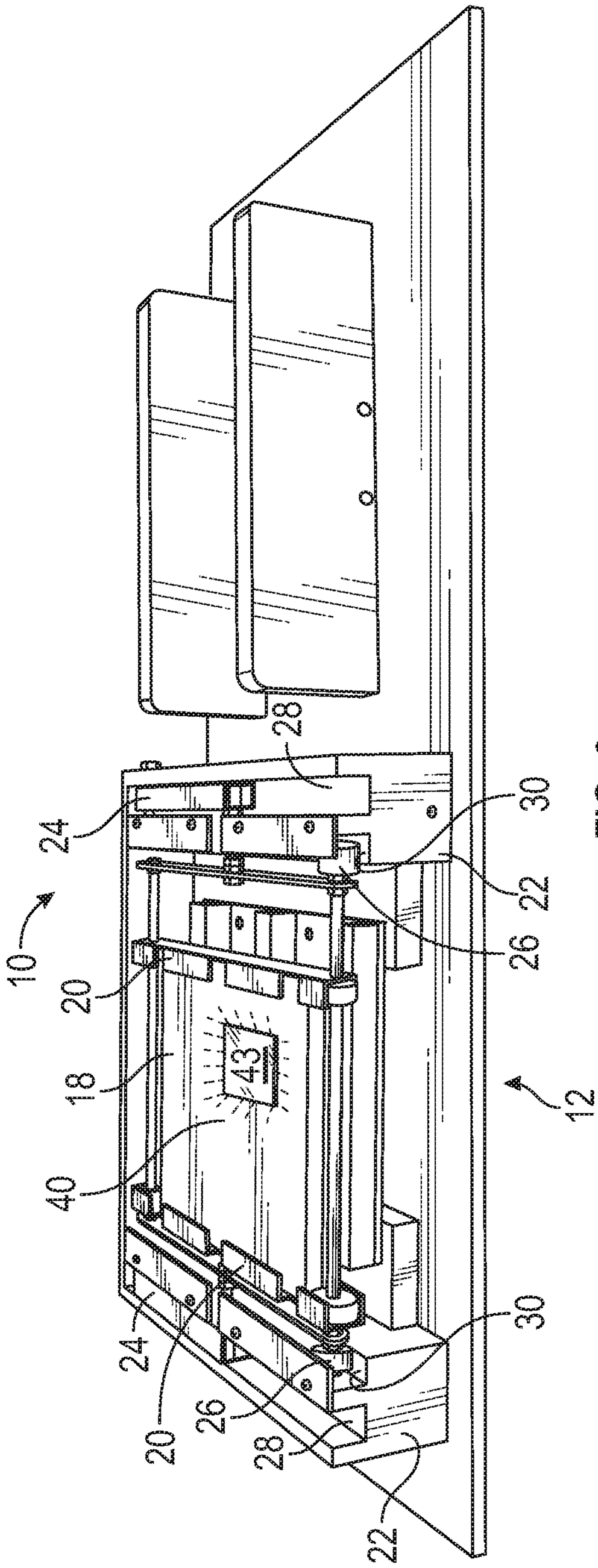

FIG. 6

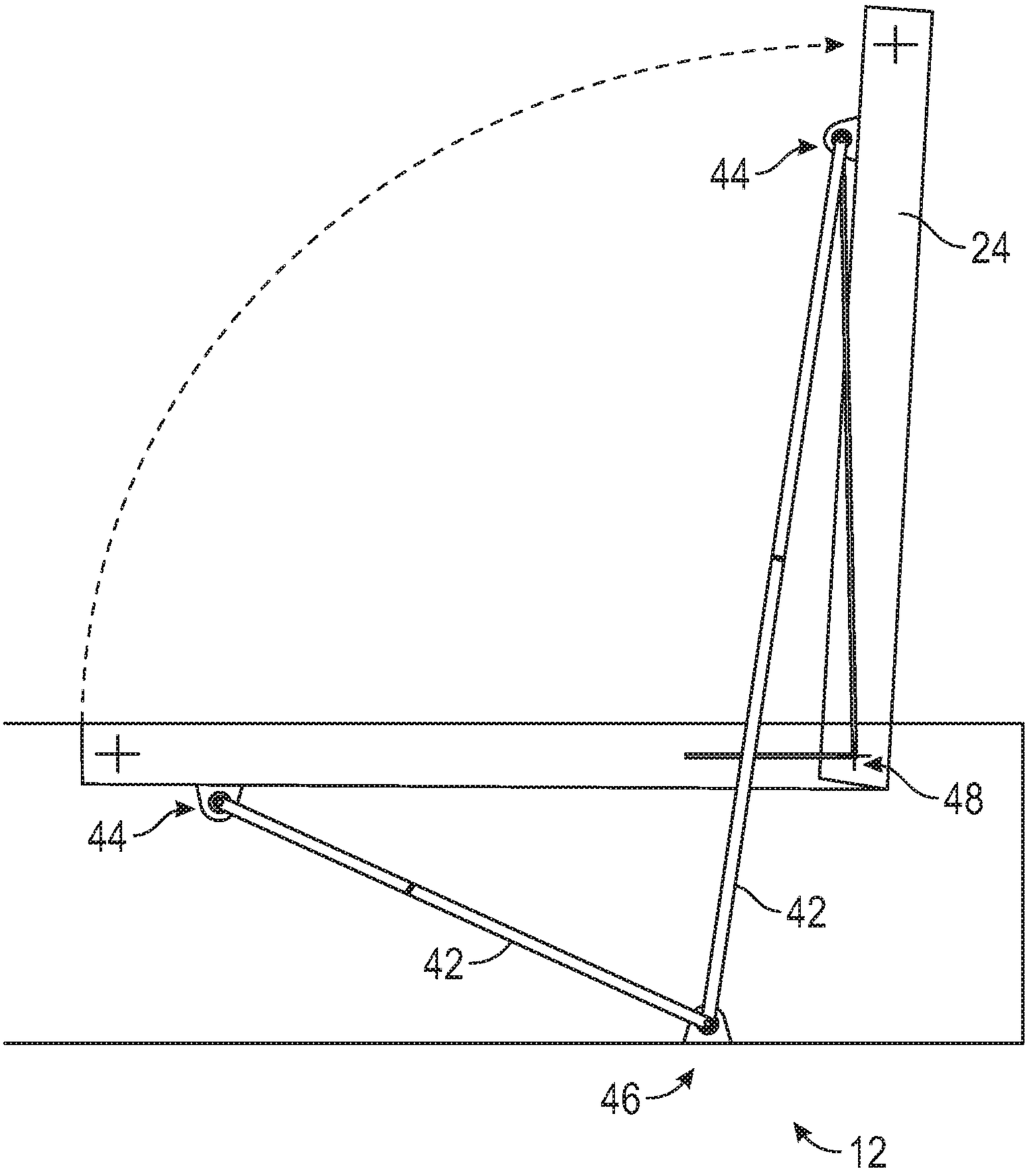

FIG. 7

WALL PANEL INVERTER AND PREFABRICATION METHOD

This application is a continuation of U.S. patent application Ser. No. 16/040,593, filed Jul. 20, 2018, which claims priority to U.S. Provisional Patent Application Ser. No. 62/534,780, filed Jul. 20, 2017, both of which are hereby incorporated by reference herein in their entireties.

BACKGROUND

This disclosure relates to devices and methods for prefabricating materials, and more particularly to a panel inverter for prefabricating wall panels and a method of doing the same.

Houses and other types of residential housing, as well as other types of housing or building construction, may include the use of a variety of prefabricated components. These constructions are experiencing a growing trend toward the use of prefabricated components, such as wall panels. Prefabricating components for construction saves time during the construction process while also decreasing manufacturing time.

Interfaces used for prefabricating panels result in large assembly lines with large footprints and may use multiple different devices to work on different surfaces of a panel, increasing manufacturing time and expense, and making it more difficult to retrofit existing assembly lines.

Given the growing popularity of prefabricated components, manufacturing processes and equipment for performing prefabrication would be able to increase speed, efficiency, and customization of the prefabricated component. There is also an increasing tendency to add other content to prefabricated walls, typically hollow cavity walls, during manufacture.

SUMMARY

In one non-limiting embodiment, an inverter manufacturing cell comprises a table including a base, a frame configured to receive a work piece, and at least one pivotable lift arm attached to the base and to the frame. The pivotable lift arm is configured to pivot relative to the base about at least one axis such that the frame and work piece rotate from a first, generally horizontal position to a second, generally vertical position. After rotating to the second, vertical position, the frame is configured to slide such that the frame and work piece further rotate to a third, generally horizontal position wherein the frame and work piece are inverted relative to the first, generally horizontal position.

In another non-limiting embodiment, a method of using an inverter manufacturing cell includes providing a table including a base, a frame configured to receive a work piece, and at least one pivotable lift arm attached to the base and the frame. The work piece is received in the frame. The lift arm is pivoted relative to the base about at least one axis to rotate the frame and the work piece from a first, generally horizontal position to a second, generally vertical position. Subsequent to pivoting the lift arm, the frame is slide to further rotate the frame and work piece to a third, generally horizontal position wherein the frame and work piece are inverted relative to the first, generally horizontal position. At least one manufacturing process is performed on the work piece subsequent to either the pivoting step, the sliding step, or both.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a PIM Cell and associated component in a first position.

FIG. **2** is a perspective view of a PIM Cell and associated component in a second position.

FIG. **3** is a perspective view of a PIM Cell and associated component with lift arms raised.

FIG. **4** is a perspective view of a PIM Cell and associated component with lift arms in a partially lowered position.

FIG. **5** is a perspective view of a PIM Cell and associated component with lift arms in a position lower than that of FIG. **4**.

FIG. **6** is a perspective view of the bolt and the lock interface insert of FIG. **5** in an uninstalled position.

FIG. **7** is a perspective view illustrating movement of the lift arm between a first position and a second position.

These and other features disclosed herein can be best understood from the following specification and drawings, the following of which is a brief description.

DETAILED DESCRIPTION

FIGS. **1-6** illustrate, in a number of different positions, a perspective view of an inverter-manufacturing cell, such as a panel inverter-manufacturing ("PIM") cell **10** used to hold and move wall panels or similar types of products for manufacturing. The PIM cell **10** includes a table **12** and a panel holder **14**. In one example, the panel holder **14** includes two struts **16** spaced apart to support at least one work piece, such as a panel **18**. Other types of panel holders **14** such as a single piece panel holder may be used. Although not shown, panel holder **14** may incorporate an automated system configured to move the panel **18** to the table **12**. Such automated system (not shown) may include a conveyor, wheels or a belt to slide the panel **18**, or alternatively may be a separate machine that is configured to move the panel **18** to the table **12**.

In one example, the panel **18** is a prefabricated wall panel having hollow cavity walls. The example panel **18** has a rectangular geometric profile; however, other geometric profiles may be used that are attachable to the table **12** and provide further ease of manufacturability using the PIM cell **10**.

The table **12** includes the frame **20** that is configured to hold panel **18** in place during operation of the PIM cell **10** and an adjustable work piece, such as a conveyor **38**. The conveyor **38** includes a top surface to hold the panel **18**. The conveyor **38** is adjustable to align the surface holding the panel **18** with the top surface of the frame **20** to facilitate moving the panel **18** into a frame **20**. Once the panel **18** is secured within the frame **20**, the conveyor **38** can lower itself to avoid interfering with the operation of the rest of the PIM cell **10** and corresponding manufacturing processes.

The frame **20** is adjustable to hold different sized panels **18**. The table **12** also includes a base **22** and lift arms **24** moveably attached to the base **22**. In this example, two lift arms **24** are shown and arranged parallel to one another in two parallel slots **28** of the base **22**. The lift arms **24** are arranged to move relative to the base by pivoting about at least one axis **23**. In this example, the axis **23** is near the center of the frame **20** and of the respective slot **28**. The lift arms **24** are hinged at one end and pivot out from the base **22** from a position parallel with its respective slot **28** to a position perpendicular or nearly perpendicular to respective slot **28**.

The lift arms **24** are attached to frame **20** and configured to move frame **20** between a first position and a second position. In one example, the frame **20** is rotated by lift arms **24** between 0° and 180° as will be described in further detail

below. In this manner, the lift arms **24** can pivot the frame **20** to multiple different positions.

The frame **20** is also attached to wheels **26**. Each wheel **26** is disposed in a respective track **30** that is generally parallel to slots **28**. The wheels **26** are moveable along a respective track **30** to move the frame **20** such that the frame rotates. The wheels **26** in combination with the lift arms **24** provide rotation of the frame **20** between 0° and 180° without having to remove the frame **20** from the table **12**.

In one example, the frame **20** is adjustable to hold panels **18** with a height up to about 12 feet, a length up to about 16 feet and a thickness between about 3.5 inches to about 8 inches.

A controller **32** in communication with the PIM cell **10** is configured to move the frame **20** using lift arms **24** and wheels **26** to any position necessary to perform manufacturing processes. In this manner, the panel **18** can be held at various positions and angles to permit work on the panel **18**. The controller **32** communicates with linear actuators, or other actuators, to allow for synchronized movement of the lift arms **24**. In one example, the actuators include sensors for position sensing to provide synchronized movement of the lift arms **24** without mechanic linkages between the respective lift arms **24**. Proximity sensors may also be used for providing synchronized movement of the lift arms **24**.

In operation, as shown in FIG. **1**, the panel **18** is slid linearly onto conveyor **38**. In this example, the conveyor **38** is a raised conveyor **38** such as a skate wheel roller track. However, other types of conveyors **38** may be used. The conveyor **38** now holding panel **18** is adjusted until the top surface of the panel **18** is flush with the tops surface of the frame **20**.

Referring to FIG. **2**, the panel **18** is resting within the frame **20** with a first side **34** facing outward. A sliding clamp **36** running lengthwise forms one side of the frame **20**. The sliding clamp **36** slides toward the opposing side of the frame along linear guides **39** arranged near the ends of the frame **20**. The sliding clamp **36** is moved towards the opposite side of the frame **20** until the panel **18** is securely held in place within the frame **20**. In one example, the sliding clamp **26** is on any side of the frame **20** and is arranged to move towards the opposite side of the frame **20** to secure the panel **18** in the frame **20**. The conveyor **38** is then retracted into the bottom of table **12**. The conveyor **38** may be covered to form a level floor and working area within the PIM cell **10** to provide ease of access and manufacturing on the panel **18** when in a desired position, as will be described in further detail below.

Referring to FIGS. **2** and **3**, the frame **20** is attached to table **12** at each end by axles attached to lift arms **24** that form hinge points near the center of the frame **20**. The lift arms **24** raise and lower the frame **20**. The frame **20** is also attached by wheels **26** located near the outer corners of the frame **20**. In one example, the wheels **26** are at an end opposite the sliding clamp **36**. The wheels **26** are set in the tracks **30** and move provide additional rotation of the frame **20**. The tracks **30** guide the wheels **26** as well as preventing them from rising off of the track to the frame **20** is safely restrained.

In one example, at least one additional wheel may be used to move sliding clamp **36**. In one example, three wheels **26** on single axles are used within the PIM cell **10**.

Referring to FIG. **3**, the lift arms **24** are actuated upwards rotating the frame **20** with secured panel **18** into an upright position. When lift arms **24** reach a near perpendicular position, wheels **26** are aligned with hinge points of the lift arms **24**. In this position a second side **40** of the panel **18** is now visible.

Referring to FIGS. **4-6**, wheels **26** move down tracks **30** away from the hinge point of the lift arms **24** to continue to rotate the frame **20** and panel **18**. At the same time, lift arms **24** retract to rotate the frame **20** and panel **18**. Wheels **26** move such that the frame **20** and panel **18** become inverted from the beginning position shown in FIG. **2**. In this manner, second side **40** is now facing outwards. The frame is moveable to any desired position and location for ease of work processes and manufacturing. Example non-limiting positions are shown in FIGS. **4**, **5** and **6**.

The process described in FIGS. **2-6** may be reversed to return the frame **20** and panel **18** to its original position with first side **34** facing outwards. Once back in the original position, the panel **18** can be removed from the frame **20** for further manufacture or shipping.

In one example, the frame **20** is assisted in moving in the desired direction at the point of inflection when the frame **20** is raised vertically. A spring, or pusher device, (not shown) is used to push the wheels **26** away from the lift arms **24** to the opposite side of the table **12**. This prevents the wheels from jamming and preventing the frame **20** and panel **18** from inverting.

In another example, the frame is assisted in moving in the desired direction after the point of inflection by shaping tracks **30** to be sloped downward toward the center of the table **12** on both sides. The slope of the tracks **30** biased the wheels **26** to release in a direction towards the center of the table **12** as the lift arms **24** lowered. By sloping both sides of the tracks **30** downward toward the center of the table **12**, a level plane is maintained when the lift arms were completely lowered.

The PIM cell **10** allows the panel to be stopped and held in place at any point along the tracks **30** and in an inverted position to permit work on the panel **18** in any number of positions, and on either side of the panel **18**. This allows the manufacturer to perform tasks **43** on the panel **18** in the optimal position: horizontal, vertical, or any position in-between. After work is completed, the panel **18** can be returned to its original orientation for shipment to a site for installation and use.

Referring to FIG. **7**, the lift arm **24** is shown in a horizontal position and a vertical position. A hydraulic cylinder **42** is shown and used to raise and lower the lift arm **24**. The hydraulic cylinder is attached to the lift arm **24** at a first location **44** and to the table **12** at a second location **46**. The example attachment configuration allows the frame **20** and panel **18** (not shown) to act as a counterbalance reducing lift loads and maintaining the majority of the weight on the end corresponding to the second location **46**. In this example, the second location **46** is about 1 foot beneath the outer edge of the PIM cell **10**.

In this example, when in the vertical position, the first location is about 7 feet from the outer edge of the PIM cell **10** to provide rotational direction. The example arrangement further reduces the overall height of the PIM cell **10** and the frame **20** when in an upright position, improving reach height for operators when working on the panel **18** in the vertical position. This example arrangement also allows the PIM cell **10** to operate under lower ceiling heights.

In this example, the distance between the first location **44** and the second location **46** when in the horizontal position is about 4 feet. The distance between the first location **44** and the second location **46** when in the vertical position is about 9 feet. When the frame **20** is at full extension i.e. vertically

aligned to be as tall as possible, a hinge point **48** of the frame **20** is at an angle less than 90° relative to the first location **44**.

Although the different embodiments have the specific components shown in the illustrations, embodiments of this disclosure are not limited to those particular combinations. It is possible to use some of the components or features from one of the embodiments in combination with features or components from another one of the embodiments.

The preceding description is exemplary rather than limiting in nature. Variations and modifications to the disclosed embodiments may become apparent to those skilled in the art that do not necessarily depart from the essence of this disclosure.

What is claimed is:

1. An inverter manufacturing cell comprising:

a table including a base, a frame configured to receive a work piece, and at least one pivotable lift arm attached to the base and to the frame, wherein the pivotable lift arm is moveable relative to the frame and configured to pivot relative to the base about at least one axis such that the frame and work piece rotate from a first, generally horizontal position to a second, generally vertical position, wherein after rotating to the second, vertical position the frame is configured to slide such that the frame and work piece further rotate to a third, generally horizontal position wherein the frame and work piece are inverted relative to the first, generally horizontal position.

2. The inverter manufacturing cell of claim **1**, wherein the pivotable lift arm is configured to rotate the frame to move the work piece to any position between the first, generally horizontal position and the second, generally vertical position, and between the second, generally vertical position, and the third, generally horizontal position such that a manufacturing process can be performed on either side of the work piece at different angles.

3. The inverter manufacturing cell of claim **1**, wherein the at least one pivotable lift arm comprises two pivotable lift arms each attached to the base and to the frame, wherein the frame is disposed between a first of the two pivotable lift arms and a second of the two pivotable lift arms.

4. The inverter manufacturing cell of claim **3**, wherein the first of the two pivotable lift arms is attached to the frame at a first location and the second of the two pivotable lift arms is attached to the frame at a second location, wherein the second location is on an opposite side of the frame from the first location.

5. The inverter manufacturing cell of claim **1**, wherein the at least one pivotable lift arm comprises two pivotable lift arms arranged parallel to one another in two parallel slots of the base, wherein the two pivotable lift arms are hinged at one end.

6. The inverter manufacturing cell of claim **5**, wherein movement of the two pivotable lift arms is configured to be synchronized without mechanic linkages between the respective two pivotable lift arms.

7. The inverter manufacturing cell of claim **5**, further comprising a controller configured to communicate with at least one actuator to allow for synchronized movement of the two pivotable lift arms.

8. The inverter manufacturing cell of claim **1**, wherein the frame is attached to wheels configured to move in parallel tracks such that the frame is slidable.

9. The inverter manufacturing cell of claim **1**, wherein the frame is adjustable to hold different sized work pieces.

10. The inverter manufacturing cell of claim **9**, wherein a first side of the frame comprises a sliding clamp, wherein the sliding clamp is configured to slide toward a side opposite the first side to adjust the frame until the work piece is held in the frame.

11. The inverter manufacturing cell of claim **1**, wherein the work piece is a prefabricated wall panel, and wherein the table includes a conveyor having a top surface to hold the work piece, wherein the conveyor is adjustable to align the top surface with a frame top surface to facilitate moving the work piece into the frame.

12. The inverter manufacturing cell of claim **1**, wherein when, after rotating to the second, vertical position the frame is configured to slide such that the frame and work piece further rotate to a third, generally horizontal position wherein the frame and work piece are inverted relative to the first, generally horizontal position, the frame is further configured to rotate relative to the at least one pivotable lift arm.

13. The inverter manufacturing cell of claim **12**, wherein a frame first end and a pivotable lift arm first end each extend away from the base in the second vertical position, wherein the frame first end is configured to move in a direction opposite the pivotable lift arm first end when the frame and work piece further rotate to the third, generally horizontal position.

14. A method of using an inverter manufacturing cell comprising:

providing a table including a base, a frame configured to receive a work piece, and at least one pivotable lift arm attached to the base and the frame;

receiving the work piece in the frame;

pivoting the lift arm relative to the base about at least one axis to rotate the frame and the work piece from a first, generally horizontal position to a second, generally vertical position;

subsequent to pivoting the lift arm, sliding the frame to further rotate the frame and work piece to a third, generally horizontal position wherein the frame and work piece are inverted relative to the first, generally horizontal position; and

performing at least one manufacturing process on the work piece subsequent to either the pivoting step, the sliding step, or both.

15. The method of claim **14**, wherein the steps of pivoting the lift arm and sliding the lift arm rotate the frame to move the work piece to any position between the first, generally horizontal position and the second, generally vertical position, and between the second, generally vertical position, and the third, generally horizontal position such that the step of performing at least one manufacturing process can be performed on either side of the work piece at different angles.

16. The method of claim **15**, further comprising the step of providing a prefabricated wall panel holder including a plurality of prefabricated wall panels; and moving one of the plurality of prefabricated wall panels onto a conveyor of the table for placement in the frame.

17. The method of claim **14**, wherein the at least one pivotable lift arm comprises two pivotable lift arms arranged parallel to one another in two parallel slots of the base, wherein the two pivotable lift arms are hinged at one end.

18. The method of claim **17**, further comprising the step of communicating with at least one actuator via a controller to synchronize movement of the two pivotable lift arms.

19. The method of claim **14**, wherein the frame is attached to wheels and wherein the step of sliding further comprises moving the wheels in parallel tracks.

20. The method of claim **14**, wherein the at least one pivotable lift arm comprises two pivotable lift arms each attached to the base and to the frame, wherein the frame is disposed between a first of the two pivotable lift arms and a second of the two pivotable lift arms.

21. The method of claim **14**, further comprising the step of adjusting the frame to correspond to the size of the work piece, wherein the work piece is a prefabricated wall panel.

22. The method of claim **14**, wherein the table includes a conveyor and further comprising the step of adjusting the alignment of a top surface of the conveyor to align with the top surface of the frame; and moving the work piece into the frame.

23. The method of claim **22**, further comprising retracting the conveyor to the bottom of the table and covering the conveyor to form a level working area.

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